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Computer-assisted learning to read and spell: results from two pilot studies

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ABSTRACT

Because multimedia computer programs may provide promising opportunities for the training of initial reading and spelling skills, two small-scale pilot studies have been conducted with a recently-developed program to examine its efficacy and impact on the motivation of the users. The first study is concerned with the use of the program in kindergarten children (K2). As there is no curriculum for these children, a computer program that is fully adaptive may well boost their independence in learning to read and spell. The main finding in this study was that kindergarten readers learned in up to 16 hours of computer practice as much as is normally attained in the first 3 months of formal reading instruction in the classroom. In the second study, reading-disabled students with low levels of motivation engaged in computer-based spelling practice. The most important finding in this study was that the amount of non-task directed behaviour of those who had practised with the computer significantly decreased during both computer sessions and classroom sessions. In the discussion the way in which computers can be used most efficiently for the instruction of reading and spelling is analysed and suggestions for further research and development are presented.

INTRODUCTION

Reading is a skill that is taught formally in schools as a matter of public policy. Some children, however, seem to acquire reading skills independently, before they receive formal reading instruction at primary school, although some may receive help from home. On the other hand, some youngsters experience serious difficulties in learning to read. The present research addresses the question of whether these two quite different groups of pupils can both benefit from using a multimedia computer program for learning to read and write.

Kindergarten children

When children enter the second year of primary school (in the Netherlands: K1, K2, G1 through G6) it is already apparent that they differ considerably in many ways, including motivation, independence, intelligence and reading readiness. Some children can already read a few words and know some of the letter names and/or sounds. They are good at phonological skills which are widely believed to be positively related to reading proficiency (e.g. Bradley and Bryant, 1983). They know already what reading and writing is all about (e.g. Sulzby, 1985). These children, who are likely to make exceptionally rapid progress in beginning literacy, often create a differentiation problem for their teachers, especially where no formal reading instruction is provided (e.g. see Dooley, 1993). Should these children be encouraged and stimulated in their independent attempts to learn to read and spell, or should they be forced to follow the mainstream curriculum, which is soon likely to demotivate them, because they will be asked to 'learn' things they have already mastered? On the other hand, if precocious learners are allowed to learn at their own level of competence and at their own pace, providing them with opportunities to acquire reading skills will be more challenging for them. Moreover, once a child can read, the activity of reading facilitates further learning and enables the child to become relatively independent of the teacher (Share, 1995). So the question is: How can we assist the K2 teachers in providing instruction and practice adapted to the individual needs of the child who is ready to read?

Children with reading difficulties

There is now substantial converging evidence that most cases of specific reading difficulty arise because of poor word recognition, which, in turn, is attributable to deficiencies in the process of phonological recoding, whereby letter patterns are transformed into phonological codes. The precursor to the phonological recoding difficulty seems to be a deficit in segmental language skills, i.e. in phonological awareness or phonological sensitivity (Rack, Snowling and Olson, 1992). A major objective in recent research is the prevention and treatment of reading difficulties. Remedial tuition for failing readers is carried out by human personnel, which has wide-ranging resourcing implications (financial, staffing, training, logistic, etc.). A case in point is *Reading Recovery* (Clay, 1993), a programme in which special instruction and individual one-to-one training at the classroom level is implemented. An alternative, and possibly more cost-effective, way in which to address the problem is to use computer-assisted learning activities.

Computers and learning to read and spell

Individual computer-based reading and spelling offers good prospects for delivering literacy instruction adapted to the specific needs of both precocious readers and reading-disabled children. If appropriately programmed, the computer will automatically adjust its responses to the actions of the learner. A range of computer-mediated or computer-assisted activities for reading and spelling has been developed over the last few years and shows promising results (e.g. Leong, 1992; Olson and Wise, 1992). Olofsson (1992) created a computer program using a Scandinavian

text-to-speech unit, which allowed children to read a text on the monitor and to use a mouse to request the immediate pronunciation of a word. This relatively simple way of partially compensating for word decoding problems was much appreciated by Grade 2 children and their understanding of texts was found to be higher when using computer-aided reading. Older children with reading problems also benefited from using this program. Elbro, Rasmussen and Spelling (1996) developed and refined a similar system and evaluated the effect of different types of feedback.

In the studies reported in this paper, a group of 'reading-ready' kindergarten children and a group of reading-disabled children, who also had motivation problems, engaged in computer-based reading and spelling using a new multimedia program called *Leescircus* (trans. 'Circus of Reading'), developed by PI Research, Amsterdam. The main features of this software package include spoken instructions and corrective feedback; availability of the sounds of letters, letter clusters, and words; and highly structured tasks for practising reading and spelling. In order to train phonological skills and isolated letter-sound correspondences a high quality of speech intelligibility is required. *Leescircus* features highly intelligible digitised speech providing a large amount of supportive feedback to the student (see Van Daal and Reitsma, 1993; Spaai, 1994; Spaai, Reitsma and Ellermann, 1991). With a flexible control system, it quickly adapts to the students' increasing competencies and skills.

The interactive reading programme *Leescircus* provides 'drill-and-practice' exercises, designed to give immediate (corrective) feedback in the learning process, and is intended to be a supplement to the regular reading curriculum. The pupils are able to work independently with the program to relieve the teacher of some of the burdens of teaching, and the instructions and comments are given in spoken form, because beginners naturally have problems in understanding written comments.

Although Reinking and Bridwell-Bowles (1991) caution against over-optimism, there have been a number of recent studies demonstrating positive effects of various computer-based methods for training reading related skills. However, there are shortcomings in most of the evaluated programs to date. First, they generally lack advanced and user-friendly systems for the administration of individual pupils in order to individualise the training. Second, hardly any have been designed to give a comprehensive training for the early stages of phonological skills acquisition. Third, most provide activities designed primarily for practice, rather than acquisition of new skills. The diagnostic and prescriptive systems within these programs are poorly developed, and none has strong tutorial capacities. Arguably, the introduction of technological innovations into classrooms has often been unsuccessful because extra burdens for teachers have been created. By contrast, an Integrated Learning System (ILS), which takes care of the continuous assessment of a student's previous accomplishments and current learning needs, could 'manage' that student's learning with minimal teacher intervention, thus requiring less teacher effort compared with other computer applications.

Leescircus

The newly-developed multimedia program *Leescircus* is an innovative instructional system that provides the beginning reader and children who have reading problems with exercises designed to stimulate skills identified as important to successful reading acquisition. It delivers a variety of engaging exercises for pupils and provides

feedback and/or supplementary instruction where necessary, tailoring responses to the level of the students.

The program is subdivided into several sections, each concentrating on skills critical to certain stages of reading development. In the first section there is a strong emphasis on stimulating pre-reading skills. Using pictures and sounds, the emerging reader is introduced to the concept that there is more to words than their meaning. The children's vocabulary is expanded by means of exercises using pictures and high-quality digitised voice. Other exercises are designed to draw children's attention to the phonological structure of words, e.g. to synthesise a word from the phonemes presented by the system, or to discover the position of a phoneme within a word. Then the children are introduced to the alphabetical principle – i.e. the correspondences between letters and sounds – and the first experiences with written words are provided. Exercises are designed to automatise reading ability, by stimulating the child to decode words with increasing speed and accuracy. The children also engage in simple spelling exercises, such as typing a word that is briefly seen or heard. *Leescircus* includes the following exercises:

- *Vocabulary*: matching pictures with spoken words.
- *Position of Sound*: indicating where a sound is heard in a spoken word.
- *Letter with Sound*: indicating which letter sound is heard.
- *Point at Letter*: pointing at a requested letter in the context of a word.
- *Word Closure*: filling in a missing letter.
- *Word and Picture*: matching written words with pictures.
- *Which Word*: selecting a word by its sound.
- *Visual Dictation*: spelling a word that is already written on the screen.
- *Build a Word*: spelling a word by its sound.

The level of difficulty can be varied within each exercise, bringing the total number of different exercise formats to 27. The scenario for all exercises is a circus. An example of an exercise focussing on phonological awareness training is one in which the position of a phoneme within a word must be located. A picture of a word is shown and the word's sound is spoken by the computer (see Figure 1; note that on-screen the image is in colour). The sound is delivered any time the child clicks on the picture. Underneath the picture of the fence (in Dutch: /hek/) are three clowns without mouths, and one with a mouth. Clicking on the mouth gives the sound of one of the word's phonemes: /h/, /e/, or /k/. The child is instructed to drag the mouth to the clown that corresponds to the position of the sound within the word: first, middle, or end. Another exercise is that of building a word (see Figure 2; note that on-screen the image is in colour). When the child clicks on the clown he speaks the word to be spelled. From a limited number of letters the correct letters must be dragged consecutively to the box with the black square.

Leescircus can be used as a training tool for independent use by children who appear to be progressing normally, because the materials can easily be adapted to complement any existing reading scheme. But the program is also beneficial for children who have difficulties in mastering certain aspects of reading. It is possible to assign a package of exercises that target the skills in need of remediation and thus to prevent reading difficulties from persisting. Using *Leescircus* the child can work independently from the teacher, who is then free to devote attention to other children. The user is presented with the instructions by a high-quality digitised voice.

Figure 1. Example screen: *Position of Sound*.

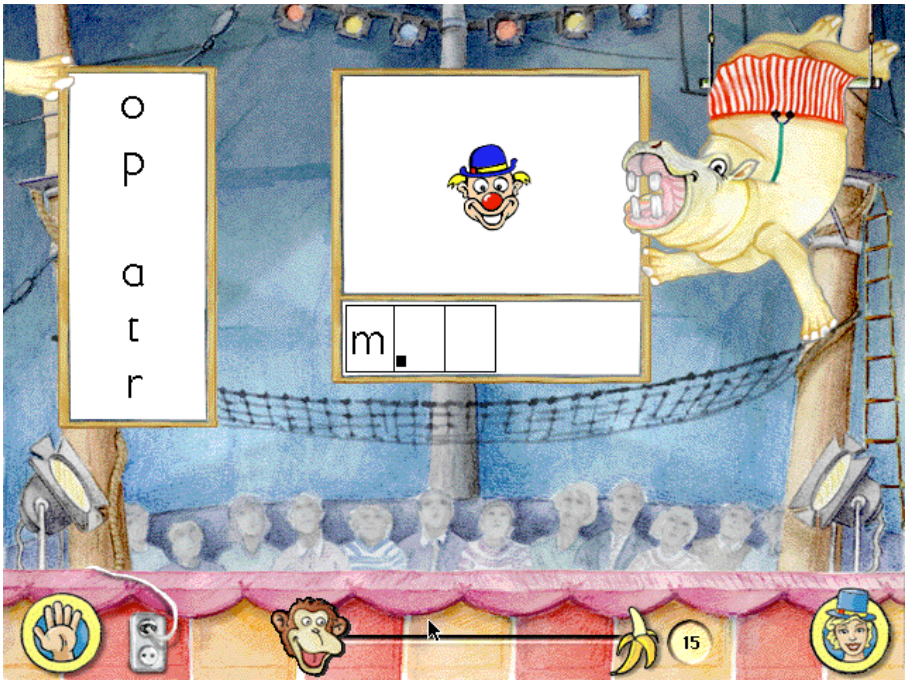

Figure 2. Example screen: *Build a Word*.

In the early exercises only mouse control is required, allowing kindergarten children to use the program without difficulty. The keyboard is used later on. Actions by the user are monitored and appropriate responses are given by the computer, using an extensive feedback system. The practicality and ease of use of the program also extend to the administrator. The administrator (teacher, researcher) can swiftly set up exercises for the children. Even tailored packages of exercises can be assigned by using the menu-driven system. The administrator can also determine the level of feedback and the type of instructions children will receive.

Leescircus is designed in such a way that new exercises can easily be added. It can even receive content from other languages, so it can readily be used in cross-linguistic research involving different schooling systems, teaching practices, and languages. An earlier version of *Leescircus* has been translated into Swedish (cf. Olofsson and Van Daal, 1994). A first evaluation (Olofsson and Gruber, 1996) indicates that all the six-year olds in the study could use the program, even the pupils lacking knowledge about print and sounds at the time of starting the exercises. The latest version of *Leescircus* is currently being translated into English.

In the remainder of this article two pilot studies of computer-based reading and spelling with *Leescircus* will be presented.

STUDY 1:

Kindergarten children and computer-assisted reading

The aim of the first study was to examine how kindergarten children can independently acquire initial reading and spelling skills by means of computer-assisted practice. Some of the children were allowed to practise reading and spelling with the help of the computer; others were not given access to the computer, but engaged in usual classroom activities. After the period in which the computer was available, all children were tested on relevant reading and spelling tasks. The children who were given access to the computer were also tested before the period of training. We hypothesised that the children who were allowed practice using the computer would learn more with respect to reading skills than children who had no access to the computer. However, it is probable that all children would also have other opportunities to engage in informal reading training, either at home or at school.

Method

Participants

Teachers of two classes with K2 kindergarten children in a primary school in the Rotterdam region were asked which pupils in their class they thought would be ready to learn to read and write. (It should be explained that formal training in reading and spelling starts at the beginning of Grade 1 in the Netherlands, when the children are, on average, 6½ years old.) Twenty-one children were selected, of whom nine were randomly assigned to the Experimental group that took part in the computer-based reading. The remaining thirteen formed the Control group: these children were considered ready to learn to read and write, but were not given access to the computers. For the Experimental group the mean score on the short version of a standardised Dutch intelligence test (Bleichrodt, Drenth, Zaal and Resing, 1984) was 117.9 IQ

points (*s.d.* = 6). The highest score was 127, the lowest 109. On all subtests for reading readiness (Struiksma, Van der Leij and Vieijra, 1992) – including auditory discrimination of letter sounds, concepts about reading and writing, repeating spoken words, visual analysis and discrimination of letters, synthesis of sounds, and letter knowledge – the Experimental group scored at a level that is usually attained upon entering Grade 1. Thus, insofar as reading readiness can be measured validly and reliably, the selected children in the Experimental group appeared to be somewhat advanced in comparison to chronological age peers. Unfortunately, due to time constraints, no children in the control group could be pretested.

Design and procedures

After pre-testing the children, two computers were allocated in the school for a period of 4 months. The computer program used was an earlier version of *Leescircus* that ran on Macintosh 86030 computers. The teachers were instructed how to switch the apparatus on and off. The only other task for the teachers was to allow the children of the Experimental group to practise every now and then. An experimenter visited the school weekly and made a copy of the practice results, inspected the results and assigned (new) tasks to the individual pupils (in this version there was not yet an automatic assignment of tasks). If pupils still made errors or when they needed more time to complete particular tasks, the experimenter adjusted the program options to make the tasks easier. Children who made progress were assigned new, more difficult, tasks. Thus, the computer-based practice was differentiated on the basis of the learning results. By the end of the school year all children were assessed by means of three post-tests: (1) naming letters; (2) a standardised Dutch test for word recognition (Brus and Voeten, 1973); (3) a standardised Dutch nonword reading test for the measurement of decoding skill (Van den Bos, Scheepstra and Lutje Spelberg, 1993).

Results

The amount of time taken in completing the tasks on the computer was, on average, 3 hours 13 minutes (*s.d.* = 93 min). There was a huge variation: one child spent only 94 minutes on the computer, whereas another child spent 5 hours 43 minutes. On average, 23 tasks, each of which comprised about 20 items, were completed (minimum: 10, maximum: 35). Hardly any errors were made: two children each made one error, one child made two errors.

Comparison of pre- and post-test scores for the Experimental group showed that there were significant gains in letter knowledge but not in concepts about reading and writing (see Table 1). At post-test, the Experimental group was found to out-perform the Control group on real word reading and nonword reading (see Table 2). Because norms are available for all three tests, we can say that the Experimental group performed in letter knowledge, word reading, and nonword at the same level the average child will attain after 3 months of formal reading instruction in Grade 1 reading (Struiksma, Van der Leij and Vieijra, 1992). The overall conclusion is that subjects in the Experimental group had improved on letter naming and were able to read both more words and nonwords than the subjects in the Control group after practice with the computer.

Table 1. Pre- and post-test scores for the Experimental group for concepts about reading and writing and letter knowledge (standard deviations in brackets).

	Pre-test	Post-test	Paired-sign Test p<
Concepts about reading and writing	7.1 (0.99)	7.4 (0.97)	0.687
Letter knowledge	14.9 (8.8)	22.2 (7.5)	0.0078

Table 2. Mean word reading and nonword reading scores of Experimental and Control groups on post-tests (standard deviations in brackets).

	Experimental group	Control group	Mann-Whitney U Test; p<
Word reading	4.7 (3.6)	2.3 (5.3)	0.0275
Nonword reading	5.3 (3.9)	3.0 (6.7)	0.0342

STUDY 2:

Motivating spelling tasks on the computer

At the other end of the range of reading ability we find children who, despite years of having tried to learn to read and spell, still perform very poorly and may have become demotivated. Some will even show behavioural problems at school. There are several reasons for this. Learning is not a very pleasant activity if one is not successful, and consequently the person will probably prefer other activities, thus spending even less time on reading practice. A possible way to break through this vicious circle is to adopt a radically different learning situation in which the computer plays a key role. If the difficulty of the reading and spelling practice is matched to the level that the individual is able to accomplish – i.e. if you control your own learning process – there is more chance of experiencing success at reading. In the second study we selected pupils with low levels of motivation from a primary school for learning-disabled children and we let them practise spelling with the computer. It was expected that these pupils would not only learn more about spelling, but also show more task-related behaviour both when working with the computer and when working in the classroom. This was expected because the learning situation with the computer is generally more structured, more adapted to individual needs, and because appropriate feedback is given at appropriate levels of task difficulty.

Method

Participants

Three girls and eleven boys from several classes in a special education school participated in the study. The youngest was 8 years old and the oldest was 12 years 1 month. Their mean age was 10 years 7 months. These children were selected by

their teachers as being very poor at spelling and having serious motivation problems: more specifically, experiencing feelings of uncertainty about their learning capabilities.

Design and procedures

The group of 14 children engaged in computer-assisted spelling exercises for at least 5 minutes a day, at least three times a week for about half a year. Before and after training, a standardised spelling test was administered. In addition, two observation sessions were held, the first immediately after training had started (Time 1) and the second near the end of the training period (Time 2). During these periods the children were observed both when working individually with the computer and in the classroom during a language lesson. Learning effects were assessed by means of a standardised dictation test, and levels of motivation were assessed using the CASES system (see below). It was expected that if the computer helped in motivating a learner the children would show improvements in spelling, and would at least maintain their level of motivation while working with the computer. On the other hand, during regular classroom instruction they would be expected to become less motivated.

Hardware and software

Spelling tasks from *Leescircus* were used. The general format of the dictation tasks was as depicted in Figure 2, except that the keyboard was used to spell the words. For each child a series of practice items was prepared by the experimenter, who would increase the word difficulty and the form of presentation whenever a particular spelling problem had been mastered. The practice words (in total there were 2586 different words available for spelling exercises in the *Leescircus* program) were ordered in the same way as in most Dutch spelling curricula. The other dimension was formed by the method of presentation: first the words were visually presented for an unlimited period; then the words were flashed and the flash duration was gradually shortened; finally the words were presented by the computer in aural mode only. The child was required to type the word using the keyboard, and, in case of errors, two tries were allowed.

The following measures were automatically recorded by the computer: (1) total numbers of words presented; (2) time used for first (and, in case of an error, second try); (3) number of requests for sound presentations during first and second tries; (4) numbers of errors at first and second try. After two unsuccessful attempts at spelling the word, the computer presented both the spoken and the written form of the target word.

Assessment materials

Two assessment instruments were used, one to assess spelling ability, the other to monitor the learning behaviour. To assess spelling ability a standardised dictation test (PI-dictee; Geelhoed and Reitsma, 1999) was used. This consists of blocks of 15 words, which are each presented within a sentence, so that the meaning of the word is clear. The subjects are required to write the word. Each block comprises of words that should be mastered after a certain period of instruction.

For the monitoring of the learning behaviour an adapted version of the CASES system (Coping Analysis Schedule for Educational Settings; Spaulding and Papageorgiou, 1977) was used. This observation system includes the following categories with positive/negative scales: (1) Destruction and aggression (e.g. demolishing the computer or other things in the classroom, but also aggressive behaviour towards other pupils); (2) Drawing attention (e.g. moving around, shouting); (3) Frustration (over learning failure); (4) Manipulating others; (5) Unnecessarily requesting help; (6) Obstruction (e.g. not willing to carry out an assigned task); (7) Distracting others; (8) Day-dreaming. The subjects were observed according to a time-sampling scheme: during two session of ten minutes the behaviour of a particular child was scored every 15 seconds by a trained experimenter. For each CASES category the number of positive behaviours was computed, giving a total maximum score of 40.

Results

The mean total number of words practised was 1,079 ($s.d = 537$), with a minimum of 278 and a maximum of 2,085. The mean total number of speech feedback requests at the first try was 179 ($s.d. = 115$), and at the second try 66 ($s.d. = 50$). These figures come close to the number of errors made: at the first try 152 ($s.d. = 62$), and at the second try 43 ($s.d. = 25$). The correlations between the number of speech feedback requests and the number of errors were 0.42 for the first try, and 0.62, for the second try. The mean total number of words correctly spelled in the dictation test before computer training was 58.2 ($s.d. = 19.6$). After training on average this figure was 74.3 ($s.d. = 20.2$). The improvement was found to be statistically significant [$t = 5.77$, $p < 0.001$].

Table 3 shows the means and standard deviations for the number of positive behaviours (CASES scale) in two situations (working with computer vs. during classroom instruction) at Time 1 (at the beginning of the training) and Time 2 (near the end of training).

An analysis of variance revealed that the number of positive behaviours was greater while working with the computer than when receiving classroom instruction [$F(1,13) = 14.87$, $p = 0.002$]. There was no effect of time of measurement [$F(1,13) = 1.61$, $p = 0.227$] nor a significant interaction effect [$F(1,13) = 3.03$, $p = 0.10$]. It can be concluded that the computer-assisted spelling helped the children to improve their spelling but also played a positive role in the way they behaved during the training, although no generalisation or improvement over time was found.

Table 3. Mean number of positive behaviours (max. 40) recorded at Time 1 and Time 2 during computer activities and classroom activities (standard deviations in brackets).

	Time 1	**Time 2**
Computer activities	34.2 (7.9)	35.6 (7.2)
Classroom activities	29.7 (8.7)	22.7 (13.2)

DISCUSSION

In the first study it was found that the children who took part in the computer-based reading and spelling practice learned to name more letters, and were able to read more words and nonwords than the children who did not have access to computer-based practice. Thus both word recognition skill and decoding skill had improved. The level of reading competence that was achieved is normally attained after 3 months of formal reading instruction in Grade 1. It is evident that the learning which took place was very efficient. The children spent only between 1.5 and 6 hours, which must be regarded as relatively little time, compared to the 30+ hours that are usually needed for classroom instruction to bring children to the equivalent level. The training with the computer was very informal, as there was no timetable and no pressure to engage in practice with the computer. Effects might be much larger when working with more stringent timetables.

It should be clear that instruction and practice with computers in the first years of primary education is a very promising approach. Firstly, it enables any child who is ready to learn to read and spell to do so in a very efficient way. Secondly, brighter children can be enabled to become largely independent of their teachers. Once they have mastered reading skills, they can proceed independently because books give access to further ways of developing their learning. Thirdly, the computer may serve as a diagnostic tool: children who do not acquire elementary reading and writing skills swiftly can easily be detected, and remedial help given. Computer-based reading and spelling as utilised in this study closely matches techniques that are typically implemented for teaching gifted children: the curriculum can be compacted, learning can be accelerated, parts of instruction can be skipped where necessary, and the curriculum can be enriched in a variety of ways.

In the second study it was found that the children with low motivation and feelings of uncertainty regarding their learning capabilities showed more positive behaviour during practice with the computer and less during classroom instruction. With the help of the computer they learned to spell more words correctly. The learning rate was normal: they made about 6 months spelling progress according to the norms. There are various possible reasons for this finding. It could be that the computer boosted motivation because the task was more structured than conventional normal paper and pencil work. Feedback is continual and children probably spend more time on task, features which are both needed by low-motivated children.

Well-designed and innovative instructional systems are of no lasting value or benefit without due consideration being given to implementation and evaluation. Indeed, there have been many applications of artificial intelligence and information technology to instructional problems over the past decades that have been successful at a technical level, but which have not been well evaluated or documented from an educational point of view. One may well ask whether Integrated Learning Systems (ILS) have an impact on achievement outcomes. In a meta-analysis of results obtained in 30 studies to answer this question Becker (1992) found little conclusive evidence of an impact of ILSs on achievement. Effect sizes were in most studies between 0.05 and 0.2, indicating that differences in achievement of ILS users and non-users had only a modest educational significance. Such findings may seem disappointing, but it is our belief that many evaluation studies under-estimate the impact of ILS because they do not account for the level and quality of

implementation at the particular schools included in the studies. Research findings reported by Van Dusen and Worthen (1994) corroborate these suggestions: outcome measures reveal that with weak implementation there is little if any positive effect of ILS, whereas with strong implementation ILS has a positive impact on students' outcomes.

In future work we therefore intend to identify and document the implementation strategies that operate in varying learning environments. When the experimental pilot studies reported here are completed, the schools will be allowed to continue using the *Leescircus* program. It is then proposed to gather data in a field test in order to analyse the capabilities and limitations of both successful and unsuccessful learning environments. Our experience suggests that the role of the teacher must be considered carefully in order to make the learning process as fruitful as possible, although for some learners the computer may be a powerful means of securing relatively independent and teacher-free learning opportunities.

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REFERENCES

BECKER, H.J. (1992) Computer-based integrated learning systems in the elementary and middle grades: A critical review and synthesis of evaluation reports. *Journal of Educational Computing Research*, 8, 1–41.

BLEICHRODT, N., DRENTH, P.J.D., ZAAL, J.N. and RESING, W.C.M. (1984) *Revisie Amsterdamse Kinder Intelligentie Test* [Revision of Amsterdam Intelligence Test for Children]. Lisse, The Netherlands: Swets and Zeitlinger.

BRADLEY, L. and BRYANT, P.E. (1983) Categorising sounds and learning to read: a causal connection. *Nature*, 301, 419–421.

BRUS, B.T. and VOETEN, M. (1973) *Eén-Minuut-Test*. [One minute test of reading.] Nijmegen, The Netherlands: Berkhout.

CLAY, M.M. (1993) *Reading Recovery: A guidebook for teachers in training*. Portsmouth, NH: Heinemann.

DOOLEY, C. (1993) The challenge: Meeting the needs of gifted readers. *The Reading Teacher*, 46, 12–17.

ELBRO, C., RASMUSSEN, I. and SPELLING, B. (1996) Teaching reading to disabled readers with language disorders: A controlled evaluation of synthetic speech feedback. *Scandinavian Journal of Psychology*, 37, 140–155.

GEELHOED, J. and REITSMA, P. (1999) *PI-dictee*. [PI spelling tests.] Lisse, Netherlands: Swets and Zeitlinger.

LEONG, C.K. (1992) Text-to-speech, text, and hypertext: Reading and spelling with the computer. *Reading and Writing: An Interdisciplinary Journal*, 4, 95–105.

OLOFSSON, Å. and VAN DAAL, V.H.P. (1994) Swedish content for AdWord. Internal report, PI Research, Amsterdam.

OLOFSSON, Å. and GRUBER, M. (1996). Datorstöd i den första lästräningen i sexårsverksamhet: Observationer ifrån ett pilotprojekt. [Computer assisted learning to read in kindergarten: Observations from a pilot project]. Unpublished research report, Department of Psychology, Umeå University, Sweden.

OLOFSSON, Å. (1992) Synthetic speech and computer aided reading for reading disabled children. *Reading and Writing: An Interdisciplinary Journal*, 4, 165–178.

OLSON, R.K. and WISE, B.W. (1992) Reading on the computer with orthographic and speech feedback: An overview of the Colorado Remediation Project. *Reading and Writing: An Interdisciplinary Journal* , 4, 107–144.

RACK, J.P., SNOWLING, M.J. and OLSON, R.K. (1992) The non-word reading deficit in developmental dyslexia: A review. *Reading Research Quarterly*, 26, 28–53.

REINKING, D. and BRIDWELL-BOWLES, L. (1991) Computers in reading and writing. In R. Barr, M. L. Kamil, P. Mosenthal, and P. D. Pearson (Eds.) *Handbook of Reading Research, Volume 2*. New York: Longman, pp. 310–340.

SHARE, D.L. (1995) Phonological recoding and self-teaching: Sine qua non of reading acquisition. *Cognition*, 55, 151–218.

SPAAI, G.W.G. (1994) *The use of speech feedback in an interactive reading programme for beginners*. Unpublished Doctoral Dissertation. Eindhoven University, The Netherlands.

SPAAI, G.W.G., REITSMA, P. and ELLERMANN, H.H. (1991) Effects of segmented and whole-word sound feedback on learning to read single words. *Journal of Educational Research, 84*, 204–213.

SPAULDING, R.L., and PAPAGEORGIOU, M.R. (1977*) Observation of the coping behaviour of children in elementary schools*. San Jose, CA: San Jose State University.

STRUIKSMA, A.J.C., VAN DER LEIJ, A. and VIEIJRA, J.P.M. (1992) Diagnostiek van technisch lezen en aanvankelijk spellen. [Diagnosing beginning reading and spelling]. Amsterdam, The Netherlands: VU Uitgeverij.

SULZBY, E. (1985) Children's emergent reading of favourite storybooks: A developmental study. *Reading Research Quarterly*, 20, 458–481.

VAN DAAL, V.H.P. and REITSMA, P. (1993) The use of speech feedback by normal and disabled readers in computer-based reading practice. *Reading and Writing: An Interdisciplinary Journal, 5*, 243–259.

VAN DEN BOS, K.P., SCHEEPSTRA, A.J.M. and LUTJE SPELBERG, H.C. (1993) Het lezen van pseudowoorden en bestaande woorden [The reading of pseudo words and real words]. *Tijdschrift voor Orthopedagogiek*, 32, 158–168.

VAN DUSEN, L.M. and WORTHEN, B.R. (1994) The impact of integrated learning system implementation on student outcomes: Implications for research and evaluation. *International Journal of Educational Research*, 21, 13–24.

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